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REUSE OF CONCRETE WITHIN DOE FROM DECONTAMINATION AND DECOMMISSIONING PROJECTS

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ABSTRACT

A protocol has been developed for use in the disposition of concrete from Decontamination and Decommissioning (D&D) projects. The purpose of this protocol is to assist U.S. Department of Energy (DOE) sites in releasing concrete for re-use within the DOE complex. Current regulations allow sites to release surface-contaminated materials if they contain very low amounts of radioactivity and to possibly release materials with volumetric contamination, or higher levels of surface contamination on a case-by-case basis. In all cases, an ALARA (as low as reasonably achievable) analysis that evaluates the risks of releasing volumetrically contaminated concrete or concrete with higher levels of surface contamination, is required.

To evaluate the dose impacts of re-using radioactively contaminated material, the measured radiation levels (pCi/g or disintegrations per minute (dpm)/100 cm²) must be converted to the estimated dose (mrem/yr) that would be received by affected individuals. The dose depends on the amounts and types of isotopes present and the time, distance, and method of exposure (e.g., inhalation or external exposure). For each disposition alternative, the protocol provides a systematic method to evaluate the impact of the dose on affected individuals. The cost impacts of re-using concrete also need to be evaluated. They too depend on the disposition alternative and the extent and type of contamination.

The protocol provides a method to perform a detailed analysis of these factors and evaluate the dose and cost impacts for various disposition alternatives. Once the dose and cost impacts of the various alternatives have been estimated, the protocol outlines the steps required to release and re-use the concrete material.

INTRODUCTION

Within the next few decades, millions of cubic meters of concrete are expected to be removed from nuclear facilities across the U.S. Department of Energy Complex as a result of D&D activities. One of the challenges facing DOE's D&D program is to find an ecologically and economically sound method to deal with the large volume of concrete that will be generated. Reusing this concrete is much less expensive than disposal of the concrete at waste disposal sites. A projected savings of over \$1 billion might be expected within the DOE complex from the reuse of concrete. The overall goal of this project is to develop and deploy protocols for the free-release of concrete in accordance with DOE Order 5400.5. The three main objectives of this project are 1) development of a DOE-wide approved concrete release protocol; 2) use of this protocol on a test case at the Idaho National Engineering and Environmental Laboratory (INEEL); and 3) distribution of the protocol to other DOE sites for use. The development of this protocol was a team effort among Argonne National Laboratory – East, Vanderbilt University, and the INEEL.

BACKGROUND

Releases of material containing residual radioactivity have been ongoing within DOE for a few years, but these releases have been limited to materials with surface contamination. Explicit release levels have been prescribed for surface-contaminated materials in DOE Order 5400.5, "Radiation Protection of the Public and Environment" as amended, which was first issued on February 8, 1990 (DOE 1990). No equivalent release levels for materials with volumetric contamination are currently established. Because of this lack of explicit release standards, a process of "authorized" release for volumetrically contaminated material is permitted under the existing Order 5400.5 and the proposed rule in Title 10, Part 834 of the *Code of Federal Regulations* (10 CFR Part 834). Authorized release is based on a case-by-case (but systematic) approach that provides for the development of authorized release limits through a series of prescribed steps before approval for release is granted. Specific requirements include the following: (1) pertinent radiological characteristics are identified and specified for the materials, (2) release limits are derived to meet the as-low-as-reasonably-achievable (ALARA) objectives, (3) requisite documentation is completed and approved by DOE authorities, and (4) concurrence by appropriate stakeholders is sought and obtained.

To further clarify the provisions and to implement the policy of authorized release, the draft handbook entitled *Controlling Release for Reuse or Recycle of Property Containing Residual Radioactive Material* was published by DOE in 1997. The Handbook has been distributed throughout DOE field offices for interim use and implementation (Chen et al. 1999). The authorized release approach described in the Handbook consists of 10 steps that address the general areas of property characterization, evaluation and development of authorized limits, approval of release, verification, and implementation of release. It is important to note that authorized or supplemental limits may be derived for individual releases of non-real property (e.g., one-time sale of reusable copper wire), or for major categories of non-real property (e.g., scrap metal or office machines) that are routinely released over time. In the latter case, once authorized limits (or supplemental limits [which apply only to special conditions]) have been approved for a category, individual releases of non-real property within that category are assumed to meet ALARA requirements if compliance with the limits has been demonstrated. Therefore, the entire 10-step process is not necessarily required for each proposed release. Determining the possible existence of previously established authorized or supplemental limits applicable to the proposed release is addressed early in the 10-step process. The 10 major steps of the release process for non-real property are as follows:

1. Characterize property and prepare a description.
2. Determine whether applicable authorized or supplemental limits already exist.
3. Define authorized or supplemental limits needed.
4. Develop authorized or supplemental limits.
5. Compile and submit application for DOE Operations Office approval.
6. Document approved limits in the public record.
7. Implement approved limits.
8. Conduct surveys/measurements.
9. Verify that applicable authorized or supplemental limits have been met.
10. Release property.

The Handbook recommends actions to guide field personnel in implementing each step and provides detailed instructions and examples for some steps.

AUTHORIZED RELEASE PROTOCOL FOR CONCRETE

Characterize and Describe

The first step of the authorized release process is to characterize the property and prepare descriptions of the concrete's physical properties and radiological history. The description of the concrete's physical properties should include the amount of concrete proposed for release, and prior use of the concrete. A

written radiological history of the concrete should be developed on the basis of process knowledge. In some circumstances, it may be advisable to document the radiological history to support the certification that non-real property is neither radioactive itself nor contaminated with radioactive materials.

After the radiological history has been entered, a determination of whether the concrete contains residual radioactive material must be made. If the concrete has been determined, through the radiological history, as not being radioactive and not containing residual radioactive material, then the concrete can be released. However, if the radiological history will not support determination that the concrete does not contain residual radioactive material, then the property must be treated as either (1) known to be contaminated or previously contaminated or (2) possibly contaminated. In either case, the rest of the release process must be followed. Concrete known to be either contaminated, previously contaminated, or possibly contaminated must be comprehensively surveyed before release to demonstrate compliance with release limits.

Existing Limits

If the concrete material has been found to be either radioactive or possibly radioactive, an evaluation should be made of whether any existing release limits seem applicable to the concrete material proposed for release. If existing authorized release limits apply and are appropriate, then the release process is continued by conducting surveys and measurements. However, if release limits do not exist, are not applicable, or are inappropriate, new or amended limits must be developed.

Defining Authorized or Supplemental Limits

Authorized or supplemental release limits must be derived if release limits for the concrete materials proposed for release do not exist or are not appropriate. The specification of such limits may vary depending on (1) the physical and radiological characteristics of the concrete materials proposed for release, (2) whether the release will be a one-time occurrence or a routine process occurring over time, and (3) whether restrictions will be placed on the concrete materials proposed for release.

When use of surface release limits is appropriate, the authorized limits should be developed for both fixed and removable contamination for the known radionuclides. In addition, the survey/measurement protocols should be referenced in demonstrating compliance with the proposed release limits. These survey protocols should be included as an attachment to the authorized release application. In cases when surveying procedures are not possible, it may be possible to fashion release limits not involving residual surface concentration values if the doses reported in the ALARA section are found to be less than 1 mrem/yr to a maximally exposed individual (MEI).

Develop Authorized or Supplemental Limits (ALARA Analysis)

DOE Order 5400.5 and 10 CFR Part 834 require that an ALARA process be used if release limits must be developed. The ALARA process is an optimization process intended to identify one alternative that would reduce radiation exposures to levels that are as low as practicable from among several alternatives that are reasonably expected to meet regulatory dose limits. The process also takes economic, environmental, technological, and public policy factors into account, with the goal of maximizing total benefits. The ALARA analysis for the authorized release of concrete materials considers a range of disposition alternatives, including the following:

- A. *Decontaminate the concrete material, dispose of all low-level radioactive waste (LLW), and crush and reuse the decontaminated material as roadbed material.* The decontaminate, crush, and reuse alternative involves surface decontamination of the concrete material, disposal of the waste generated during decontamination at a LLW disposal facility, and crushing and reusing the decontaminated concrete. Any waste generated during the decontamination or crushing process is packaged and transported to an appropriate disposal facility. If the concrete material is

volumetrically contaminated, surface removal techniques may not provide adequate decontamination. Hence, this alternative only applies to surface-contaminated concrete materials.

- B. *Crush the concrete material without decontamination and reuse it as roadbed material.* This alternative provides estimates of the costs and radiological doses associated with direct reuse of the concrete without decontaminating it. Only the crushing and sorting operations would generate any waste. These wastes (rebar and fines generated during crushing operations) would be packaged and transported to an appropriate disposal facility.
- C. *Decontaminate the concrete material, dispose of all LLW, demolish the structure or material, and dispose of the decontaminated material as construction debris (placement in a nonradiological landfill) or reuse it as backfill.* Alternate C involves costs and radiological doses associated with decontamination, demolition, and disposing of the concrete material at a nonradiological landfill or using the crushed concrete as fill material. The waste generated during decontamination activities is to be packaged and transported to a LLW disposal facility. In general, the concrete material or structure is demolished after decontamination and then loaded onto a dump truck and transported to a nonradiological landfill. However, if a landfill requires the material to be packaged prior to disposal, the costs associated with packaging the material should be estimated. Radiological doses are estimated for persons living along the transportation routes for the shipments of both the waste and the demolished concrete material. Radiological doses are also estimated for persons working at the nonradiological disposal facility since their activities are not part of a radiation protection program. An estimate of the radiation dose to a future resident living at the site after landfill closure is also provided. Radiological impacts to the decontamination worker are not analyzed in this protocol since it is assumed the worker is already part of an ALARA program. However, the dose to the decontamination worker is considered in other documentation, such as the Characterization and Decision Analysis Report or the site ALARA analysis.
- D. *Demolish the concrete material and either dispose (without decontamination) of it as construction debris (nonradiological landfill) or reuse it as backfill.* Alternative D involves the costs and radiological impacts associated with demolishing the concrete material and transporting it to a nonradiological landfill for disposal or using the crushed concrete as fill material. This alternative is similar to Alternative C except the concrete material is not decontaminated before demolition and crushing (if applicable). Radiological impacts must be estimated for the driver and landfill worker because this alternative assumes that the workers are not part of a radiation protection program. However, if these workers are part of a radiation protection program, the radiological impacts to these workers do not need to be estimated. The dose to a future resident after landfill closure is also estimated for this alternative.
- E. *Demolish (without decontamination) the concrete material and dispose of all materials as LLW.* Alternative E involves the costs and radiological impacts associated with demolition, packaging, transportation, and disposal of the concrete material at an LLW facility. This alternative assumes that the truck driver is part of a radiation protection program; therefore, the dose to the truck driver is not estimated.
- F. *Decontaminate the structure (valid for building only) and reuse.* Alternative F involves the decontamination of the concrete structure, disposal of the waste generated during decontamination at a LLW disposal facility, and reuse of the decontaminated building as an office. An office building scenario was selected because of its conservatism as an exposure scenario. This scenario assumes that the

building will be occupied daily for a total of 2,000 hours per year. This approach prevents the need for administrative controls on the building use.

- G. Demolish the concrete material (with or without decontamination) or structure and entomb the demolished material. Alternative G evaluates the estimated costs and radiological impacts associated with demolishing the concrete structure or material and entombing it. For this alternative, decontamination may or may not be required. The site is released, and a person is assumed to build a house on top of the entombed material. The dose to the future resident is estimated in the same manner as that used for nonradiological landfills. If some form of radiological control is maintained at the site, it is not necessary to calculate radiological impacts associated with this alternative.

Although a number of other alternatives could be considered, those listed above represent a wide range of disposition alternatives. Each potential alternative is analyzed to determine costs and radiological doses associated with the alternative to complete the ALARA analysis.

The proposed authorized release limits are derived by selecting the alternative that minimizes the dose to members of the public while, at the same time, minimizes the total cost. Hence, the proposed authorized release limits are not only a function of the radionuclide profile and concentration but also the scenario to which they apply. For example, the authorized release could be x pCi/g for isotope Y, provided the material is decontaminated to a certain level prior to release. Authorized release limits that would result in a dose greater than 1 mrem/yr to a member of the public are allowed only with approval of the DOE Office of the Assistant Secretary for Environment, Safety and Health (EH). For values less than 1 mrem/yr, DOE Field Offices can approve the authorized release limits.

Compile and Submit Application for Approval

The application for approval of authorized or supplemental limits must be submitted to the DOE Operations Office that has direct responsibility for oversight of the activity proposing the release. While application, implementation, and approval of authorized limits for non-real property subject to surface contamination (consistent with guidelines described below) are the responsibility of DOE field and program elements, DOE Order 5400.5 requires EH-1 approval of authorized limits for residual radioactive material in mass or volume. However, authorized limits and survey protocols for residual radioactive material in mass or volume or surface contamination limits may be derived and approved by DOE Field Office managers without EH-1 approval if the following conditions are met:

1. On the basis of a realistic but reasonably conservative assessment of potential doses, it is demonstrated to the satisfaction of the responsible Field Office manager that:
 - a) The release of the concrete material will not cause a maximum individual dose to a member of the public in excess of 1 mrem in a year or a collective dose of more than 10 person-rem in a year;
 - b) A procedure is in place to maintain records of releases consistent with DOE Order 5400.5 requirements, and the survey or measurement results reported are consistent with the data reporting guideline in the DOE November 1992 survey guidance and DOE/EH-173T; and
2. A copy of the authorized limits; measurements and survey protocols and procedures; supporting documentation (including a statement that the ALARA process requirements) have been provided; and appropriate material documenting any necessary coordination with states or NRC are provided to the Office of Environment (EH-4) at least 40 working days before the authorized limits become effective. In this case, EH-4 will:
 - a) Provide written notification to the Field Office of the receipt of the material and

- b) Notify the Field Office, within 20 days of receipt, if the authorized limits or supporting materials are not acceptable; otherwise the authorized limits (including any conditions or limitations set forth by the approving DOE field elements) may be considered approved without written EH-1 approval.

Document Approved Limits in the Public Record

Approved release limits must be made part of the public record. As a matter of policy, DOE recognizes that public participation must be a fundamental component of the Department's program operation, planning activities, and decision making. As a result, each DOE site is responsible for developing its own public participation program and plans in consultation with stakeholders and with the concurrence of appropriate DOE Headquarters program offices. As part of their plans, many sites may already have established public information repositories and/or public reading rooms. Almost all DOE sites already have designated public liaisons. Details on the specific process for documenting the approved release limits in the public record are available from the appropriate DOE Field Office. Once the authorized limits have been approved and documented in the public record, the approved limits can be implemented.

Implement Approved Limits

Implementation of release limits may require development of new site-specific procedures or modifications of existing site-specific procedures. In any event, it is the responsibility of either DOE or the contractor to identify any necessary procedural changes and to follow the existing site-specific administrative process for making and activating such changes before releasing the concrete materials.

Conduct Surveys/Measurements

The appropriate survey protocols must be followed either to verify that surface and internal residual radioactive material concentrations do not exceed applicable release limits or to determine whether radioactivity can be detected on or within the possibly contaminated concrete materials. Previously conducted surveys/measurements can be used when sufficient documentation exists to meet DOE Order 5400.5 and 10 CFR Part 834 requirements. To show the absence of detectable radioactivity and compliance with release limits, the documentation should show that surveys were completed in accordance with existing site-specific procedures and should include survey results.

Verify Concrete Material Meet Release Limits

The documented results of the survey/measurements should be compared with the approved release limits to verify that the concrete materials proposed for release meet those limits. The results of this determination must be documented. Concrete materials that have been demonstrated to meet applicable, appropriate, existing authorized or supplemental release limits can be released for reuse, provided that all other release requirements have been met. Concrete materials shown to contain no detectable radioactivity can be released for any purpose after the survey results have been documented.

If applicable, existing authorized release limits are not met, an evaluation should be made to determine whether new or amended supplemental limits should be developed. Supplemental release limits are developed when existing authorized release limits are not applicable. Generally, however, every reasonable effort must be made to minimize the use of supplemental limits, which may be more or less restrictive than existing authorized limits. If supplemental limits need to be derived, the basis for the decision should be documented and the process for developing the new or amended supplemental limits should be completed again. If it is decided that supplemental limits should not be developed, concrete materials that do not meet existing limits cannot be released for reuse. In such circumstances, an alternative management approach (e.g., sending the concrete material to an LLW disposal facility) would be necessary.

Release Concrete

DOE Order 5400.5 and 10 CFR Part 834 prohibit the release of DOE non-real property (in this case, the concrete material) unless the following actions have been undertaken to protect the public and environment:

1. The concrete material has been appropriately surveyed/measured to identify and characterize its radiological condition;
2. Residual radioactive material on concrete material surfaces or interior has been determined to meet acceptable release limits;
3. Required documentation has been completed; and
4. The owner or recipient of the released concrete material has been appropriately notified of the radiological status of the property and the availability of required documentation.

Before releasing concrete material for reuse, the responsible DOE or contractor personnel must verify that these conditions have been met. Additionally, the responsible personnel must ensure compliance with other applicable laws, regulations, and policies that may not be covered in these protocols. When compliance has been verified and documented, the concrete material may be released.

CASE STUDY

This protocol was used in a case study on an already decommissioned INEEL facility. The facility was the Central Facility Area (CFA) 691 Sewage Treatment Plant (STP) and the D&D was completed in 2000. The purpose of the case study was to use the 10-step process for the different concrete structures (digester, trickle filter and primary tank, secondary tank and 691 pump house, deep well at CFA-691, and the 657 pump house) at CFA STP to reach an appropriate disposition alternative. The alternatives from the concrete protocol were compared with the disposition alternative already used in the D&D project.

Out of the seven alternatives listed in the protocol, only five were considered for this case. The two alternatives involving entombing and reuse of the structure were not analyzed because D&D requires free release of the site. Table I shows the results of this case study for one of the structures selected for this. This case study of a previously completed D&D project proved interesting in that it provided a means of comparing various alternatives available for the disposition of concrete material from this facility. It provided a way to document the project costs and worker radiation exposure estimates for the various alternatives. It also provided project managers the information needed to verify and defend their alternative selection. Such a tool can be very valuable in the planning of D&D projects.

Table I. ALARA Analysis for Trickle Filter

	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Cost					
Decon	\$34, 718	0	\$34,718	0	0
Demolish	\$3,245	\$3,245	\$3,245	\$3,245	\$3,245
Crush	\$1964	\$2.239	0	0	0
Package	\$2,200	0	\$2,200	0	\$25,482
Ship Waste	\$803	0	\$803	0	\$4,816
Ship C&D	0	0	\$151	\$172	0
LLW Dispose	\$12,367	0	\$12,367	0	\$100,490
C&D Dispose	0	0	\$1,255	\$1431	\$0
Management	\$10,000	\$10,000	\$10,000	\$10,000	\$10,000
Total	\$65, 296	\$15,484	\$64,739	\$14,848	\$144,033
Dose (mrem)					
Driver	None	None	2.86E-02	6.87E-02	None
Population	1.90E-04	None	1.99E-04	2.17E-05	3.25E-04
Worker	8.00E-01	1.92E+00	1.49E-02	3.58E-02	None
Future Resident	None	None	1.47E+00	3.53E+00	None

CONCLUSIONS

A protocol has been developed to assist D&D project managers in the selection of the most appropriate alternatives for the disposition of concrete from their projects. For concrete containing residual amounts of radioactive contamination, criteria for its disposition can be established and approved. This ten-step process is relatively easy to follow and can result in very large cost savings for the project.

The protocol was applied to a previously completed D&D project that had involved large amounts of concrete. The results indicate that the most appropriate disposition alternative had been selected for that particular project, and that the protocol provided a valuable tool for analyzing concrete disposition alternatives at D&D projects. Wide use of the protocol throughout the DOE Complex should result in very large cost savings to decommissioning programs.